09/762696

532 Rec'd PCT/PTO 12 FEB 2001

APPLICATION UNDER UNITED STATES PATENT LAWS

Atty. Dkt. No. PM 276626/T298063US/BR/her
(M#)

Invention: PACKET-SWITCHED DATA TRANSMISSION IN RADIO SYSTEM

Inventor (s): RAITOLA, Mika
HOLMA, Harri

Pillsbury Winthrop LLP
Intellectual Property Group
1100 New York Avenue, NW
Ninth Floor
Washington, DC 20005-3918
Attorneys
Telephone: (202) 861-3000

This is a:

- ☐ Provisional Application
- ☐ Regular Utility Application
- ☐ Continuing Application
  - ☒ The contents of the parent are incorporated by reference
- ☒ PCT National Phase Application
- ☐ Design Application
- ☐ Reissue Application
- ☐ Plant Application
- ☐ Substitute Specification
  Sub. Spec Filed ______________
  in App. No. ______ / ______
- ☐ Marked up Specification re
  Sub. Spec. filed ______________
  In App. No ______ / ______

SPECIFICATION

PACKET-SWITCHED DATA TRANSMISSION IN RADIO SYSTEM

FIELD OF THE INVENTION

The invention relates to a radio system and a method of transmitting packet-switched data between a transmitter and a receiver in the radio system. The invention relates particularly to a system and a method, in which the connection between the transmitter and the receiver comprises at least two logical channels, and one logical channel is used for transmitting delay-critical information.

BACKGROUND OF THE INVENTION

Circuit switching is a method in which a connection is established between users by providing the connection with a predetermined amount of transmission capacity. The transmission capacity is used exclusively by said connection during the whole connection. Known mobile communication systems, e.g. GSM-based GSM 900/DCS 1800/PCS 1900 systems and the American IS-95 radio system applying the CDMA technique, are circuit-switched systems.

Packet switching for its part is a method in which a connection is established between users by transmitting data as packets which include the actual information and also address and control information. Various connections may simultaneously use the same transmission link. In the past few years, the use of packet-switched radio systems especially in data transmission has been examined, because the method of packet switching can be applied to e.g. data transmission required when using interactive computer programs, whereby the data to be transmitted is produced in bursts. In such a case, the data transmission connection need not be allocated for the whole time, but only for the packet transmission. This way, the costs and capacity are saved considerably both when establishing and operating the network.

A further development of radio systems is especially interested in packet radio networks. In connection with the GSM system, the GPRS (General Packet Radio Service) is often referred to. Solutions allowing the packet transmission are especially being planned for the third generation mobile phone systems, such as the UMTS (Universal Mobile Telephone System).

In telecommunication, methods of error correction are generally applied, also on packet connections, to avoid and correct errors developing on transmission connections. There are basically two types of these methods:

Forward Error Correction (FEC) and Automatic Repeat Request (ARQ). The combination of these is called a hybrid ARQ. The GPRS employs the following ARQ protocol, either in its basic form or a more advanced form.

The ARQ protocol (Automatic Repeat Request) refers to a procedure which improves the reliability of the data to be transmitted by retransmitting the information to be transmitted. In accordance with the protocol, the receiver transmits a request to the sender to retransmit the transmitted data, if the receiver considers the received data unreliable. The unreliability of the data is detected by checking a check sum from the received packet, for example. So far, the protocol has mainly been used in fixed networks. A big problem of radio networks is that the transmitting channels in radio connections have a fading character. Rayleigh fading means that multipath-propagated signal components arrive in opposite phases at a receiver and thus partly cancel each other. Then the power and also the quality of the received signal decrease considerably. In addition to normal background noise the reception is further complicated by the interference of the radio connections on the same channel and on the adjacent channel. Interference and Rayleigh fading may at times have so harmful effects that the radio channel fades, i.e. its quality deteriorates so much that the data transmitted in the channel cannot be recognised. On the other hand, occasionally fading channel may at times also be of very good quality.

A more advanced form of the ARQ protocol is the hybrid ARQ, which uses the combination of the ARQ and the FEC (Forward Error Correction). The FEC means that the information to be transmitted is coded by a coding correcting errors. In accordance with the improved type II hybrid ARQ protocol developed from the hybrid ARQ, an unsuccessful transmission is combined with a retransmission in the receiver. This combination can be performed by retransmitting the data coded in the same way and combining the soft decisions in the receiver. In the retransmission, additional coding can be used instead of transmitting the same data.

This method provides the advantage that the number of retransmissions can be decreased, whereby the transmission capacity increases considerably. A disadvantage of the method is, however, that it works best when there are a lot of transmission errors, i.e. when the frame error rate (FER) is about 20 %. Then the acknowledgement messages (ACK/NACK) of the transmission units are, however, also subject to errors, which makes the sys-

tem less functional. For example, if the transmission error equals 10 % in each transmission, there are 10 % of errors after the first transmission, 1 % after the second, 0.1 % after the third transmission etc. The combining of the transmissions reduces the amount of errors, but only after the second transmission. In order to benefit from the combining, the operation point, i.e. the frame error rate of each transmission, should be higher, e.g. 20 %. This harms, however, the delay-critical information, which cannot withstand the delay caused by the combining.

BRIEF DESCRIPTION OF THE INVENTION

It is thus an object of the invention to provide a method and an apparatus implementing the method to eliminate the above problems. This is achieved by a method of transmitting packet-switched data between a transmitter and a receiver in a radio system, in which method the connection between the transmitter and the receiver comprises at least two logical channels, and that one logical channel is used for transmitting delay-critical information, and that the information to be transmitted between the transmitter and the receiver is located in given transmission units and that a method of error protection is employed in the transmission of the transmission units. In accordance with the method, a different method of error protection is employed when transmitting data and delay-critical information.

The invention also relates to a radio system comprising a transmitter and a receiver arranged to transmit packet-switched data, and in which the connection between the transmitter and the receiver comprises at least two logical channels, and in which the transmitter and the receiver are arranged to use one logical channel for transmitting delay-critical information, and that the transmitter and the receiver are arranged to transmit the information as located in given transmission units and to employ the method of error protection in the transmission of the transmission units. In the system of the invention the transmitter and the receiver are arranged to employ a different method of error protection when transmitting data and delay-critical information.

The preferred embodiments of the invention are disclosed in the dependent claims.

The invention is based on employing the hybrid ARQ method utilising the combining in such a manner that the data and the delay-critical information are separately multiplexed.

The method and system of the invention provide a plurality of advantages. By means of the method, data can have any frame error rate and delay-critical information, e.g. the acknowledgement messages (ACK/MACK) of the transmission units, can still have a good quality in the transmission due to e.g. a strong error correcting code. As a method of error correction of data, an ARQ-based method can be employed which combines the transmission unit and its potential retransmissions before decoding the transmission unit. By means of the invention, services requiring a fast transmission of high quality, such as speech and packet data, can be transmitted simultaneously as multiplexed.

BRIEF DESCRIPTION OF THE INVENTION

In the following the invention will be described in greater detail in connection with the preferred embodiments, with reference to the attached drawings, in which

Figure 1 shows an example of a radio system, to which the invention can be applied,

Figure 2 illustrates the structure of the transmitter according to the invention,

Figure 3 illustrates the structure of the receiver according to the invention and

Figures 4a and 4b show flow charts illustrating the employment of the method of the invention for data information.

DETAILED DESCRIPTION OF THE INVENTION

The present invention can be applied to radio systems using packet-switched connections. The invention can preferably be applied to broadband CDMA-based cellular radio systems, such as WCDMA and CDMA2000, but the multiple access method employed in the system is not as such substantially relevant to the invention.

The term 'transmission unit' refers to a transmission unit used in a bidirectional radio connection, which transmission unit is the protocol data unit of layer 1, i.e. the physical layer, in the seven-layer OSI model of the ISO. In the TDMA system, for example, a transmission unit may comprise one or more TDMA time slots. In the CDMA system, a transmission unit may be a limited period of time with one or more spreading codes. In the FDMA system, a transmission unit may be a limited period of time with one or more frequencies.

In hybrid systems employing a variety of multiple access methods, a transmission unit may be any combination of the examples described above. Generally it can be stated that a transmission unit is any resource on the transmission path, i.e. in the radio connection, that can be determined.

The method of the invention is used for transmitting packet-switched data between a transmitter-receiver pair in a radio system by using the ARQ protocol. Figure 1 shows an example of a radio system, to which the invention can be applied. The radio system comprises a network part 110 and a set of subscriber terminals 112, 114. The network part refers to the fixed part of the network, e.g. a base station 116, a base station controller 118, a mobile services switching centre 120 or various combinations of said parts. A subscriber terminal is e.g. a mobile phone, a phone positioned in a car or a WLL terminal (Wireless Local Loop). A transmitter-receiver pair is composed of a network part and a subscriber terminal. The network part can function both as a transmitter and as a receiver, similarly the subscriber terminal can be in both roles. There is a bidirectional radio connection 122, 124 between the network part and the subscriber terminal. In the bidirectional radio connection, transmission units are used for data transmission.

Let us first take a look on those parts in the structure of the transmitter of the invention that are substantial for the invention by means of the block diagram in Figure 2. Figure 2 includes only the blocks that are substantial for describing the invention, but it is obvious for a person skilled in the art that a common transmitter also comprises other functions and structures, which need not be described herein in greater detail. The transmitter can basically be e.g. a normal transmitter in the GPRS system, to which transmitter the modifications required by the invention are made.

In Figure 2, the transmitter uses two services, i.e. logical channels. In the first channel 200 data is transmitted and in the second channel 202 delay-critical information is transmitted. Delay-critical information can be any data transmission which does not allow great delays, e.g. retransmissions, on the transmission path. Such connections are e.g. power regulating messages, transmission rate information relating to a data channel, acknowledgement messages (ACK/NACK) of packets or e.g. speech information. Data information 200 comprising transmission units is first taken to the first channel coder 204, after which the transmission unit is stored in a memory 206 for a potential

retransmission. Thereafter, data is taken to the first transmission rate adapter 208, in which the data transmission rate is balanced as desired.

Delay-critical information 202 is taken to the second channel coder 212, from which the coded signal is taken to the second transmission rate adapter 214, in which the transmission rate is balanced.

The transmission units are taken from the first and the second transmission rate adapters 208, 214 to a multiplexer 210, in which the units are multiplexed with each other for the transmission. The combined signal is taken from the multiplexer to the third transmission rate adapter 216, in which the common transmission rate is changed, if necessary. Finally the signal to be transmitted is taken to an interleaver 218, in which the interleaving is performed to improve the transmission quality. The signal is taken from the interleaver further to radio frequency parts of the transmitter (not shown) in order to be transmitted to the transmission channel.

The memory 206 can also be located before the first channel coder 204 or also after the first transmission rate adapter 208, but in any case before the multiplexer.

Let us next take a look on those parts in the structure of the receiver of the invention that are substantial for the invention by means of the block diagram in Figure 3. Figure 3 includes only the blocks that are substantial for describing the invention, but it is obvious for a person skilled in the art that a common receiver also comprises other functions and structures, which need not be described herein in greater detail. The receiver can basically be e.g. a normal receiver in the GPRS system, to which receiver the modifications required by the invention are made.

In the receiver a signal is received by an antenna 300, from which the signal is taken to radio frequency parts 302. In the radio frequency parts, the signal is converted to an intermediate or baseband frequency, and it is taken to a demodulator 306, in which the demodulated signal is taken to a deinterleaver 308. Said components can be implemented in ways that are obvious to a person skilled in the art.

The deinterleaved signal is taken to the first transmission rate adapter 310 and a demultiplexer 312. In the demultiplexer the signal is divided into two channels used in the transmission, in the first of which channels 314 data was transmitted and in the second of which channels 316 delay-critical information, such as control information or speech, was transmitted.

Data information is taken to the second transmission rate adapter 318, from which it is taken to a combiner 320. In the combiner, a transmission unit that may have been transmitted earlier and which is stored in a memory 322 in the reception is combined with the transmission unit. The combined transmission unit is again stored in the memory for a potential retransmission. The transmission unit is taken to the first channel decoder 324, in which errors are corrected as well. If the error correction indicates that the transmission unit is received properly, the transmission unit is taken further to the other parts of the receiver. If the error correction indicates that the transmission unit is erroneous, a retransmission has to be requested of the transmitter. This can be implemented e.g. by informing a control unit 326 of the receiver of the need for a retransmission, which control unit controls the operation of different receiver parts and conveys the information on the need for a retransmission to the transmitter by using the control channel of the opposite direction of transmission. The combiner 320 and the memory 322 can also be located before the second transmission rate adapter 318, but in any case after the demultiplexer. The memory 322 can also be located after the channel decoder 324, which provides the advantage that only those transmission units are stored that need to be retransmitted. On the other hand, soft combining cannot then be used.

The delay-critical information 316 is taken from the demultiplexer 312 to the third transmission rate adapter 328 and from there further to the second channel decoder 330. It is to be noted herein that the number of transmission rate adapters both in the transmitter and in the receiver can differ from what is described above.

Thus, in the transmitter and receiver of the invention a different error correction procedure is applied to data information and to delay-critical information. If required, a stronger channel coding can be used for delay-critical information, whereby it is less subject to errors than data information.

Let us next take a closer look on handling data information in the receiver of the invention by means of the flow chart in Figure 4a.

Step 400: A receiver receives and demodulates a transmission unit.

Step 408: It is checked whether it deals with a retransmission, i.e. whether the previously transmitted transmission unit is found in the memory. If it is found, the transmission units are combined at step 410.

Step 412: The quality of the transmission unit is checked. If the quality of the transmission unit reaches a predetermined quality level, the algorithm is exited and it is moved to receive the next transmission unit.

Step 414: If the quality was not good, the transmission unit is stored. If the quality is very bad, the unit can be completely abandoned.

Step 418: A retransmission request formed on the basis of the quality of the transmission units is transmitted. The sender is now requested to retransmit the same transmission unit whose quality level did not reach the required quality level. It is moved to step 400 to receive the transmission unit.

Figure 4b illustrates the optional handling of data information. After step 400, the quality of the transmission unit is immediately checked at step 402. If the quality is good, it is proceeded to step 408 and continued as described above. Otherwise the transmission unit is stored at step 404. If the quality is very poor, the unit may be completely abandoned. At step 406, a retransmission request formed on the basis of the quality of the transmission units is transmitted. Now the sender is requested to retransmit the same transmission unit whose quality level did not reach the required quality level. It is moved to step 400 to receive the transmission unit.

The described method is basically a more advanced form of the classic ARQ protocol in such a manner that the same transmission unit is cumulated before the detection so long that the quality of the cumulated transmission unit is good enough. It is to be noted herein that this is only one example of data error correction. In the solution of the invention, other ARQ-based solutions can be applied as well, as it is obvious for a person skilled in the art.

There are various methods of inspecting the quality of a transmission unit and a packet. In the transmission, a CRC error check sum can be formed for both the transmission unit and the packet separately, on the basis of which sum the erroneousness of the transmission unit and/or the packet is checked in the reception. Other methods of forming the error check sum can be employed as well. Quality may also be defined by forming a bit error rate for the transmission unit. The quality of the received transmission unit can also be defined by forming a C/I ratio (Carrier/Interference) for the transmission unit by means of a training sequence. A few examples were herein given of defining the quality of a transmission unit or a packet, yet any other known method can be used for measuring quality as well.

In a preferred embodiment, the quality level of a combined transmission unit is determined by comparing the average quality level of transmission units with the adaptive quality threshold. The average quality level is formed e.g. by counting the mean value or by defining a numerical limit for the amount of packets of the transmission units that has to reach the required quality level. The adaptiveness means that the system may be self-learning, whereby the system optimizes its operation by changing quality limits to conform to the conditions and to maximize the efficient use of the transmission capacity.

Although the invention has been described above with reference to the example according to the attached drawings, it is obvious that the invention is not restricted thereto, but may be modified in a variety of ways within the scope of the inventive idea disclosed in the attached claims.